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**HIDALGO EQUIVITAL PHYSIOLOGICAL MONITOR
PRODUCT REVIEW AND DATA SUMMARY**

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USARIEM TECHNICAL REPORT T09-02

HIDALGO EQUIVITAL™ PHYSIOLOGICAL MONITOR PRODUCT REVIEW AND DATA SUMMARY

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14. ABSTRACT Hidalgo Equivital™ Physiological Monitor and other sensors performance monitoring of physiological status was evaluated, and human data were collected on 12 wildland firefighters (WLFF). The devices were provided to the University of Montana Center for Work Physiology and Exercise Metabolism (WPEM) to collect data relative to energy costs and thermal strain. The Hidalgo system collected, recorded and displayed heart rate (HR), respiratory rate (RR), body position, core temperature (CT), and skin temperature (ST). CT was obtained using the VitalSense® monitor with ingestible temperature pills. Other sensors were an ActiCal® activity monitor and a Garmin Forerunner® 301 GPS. Relative to other devices used by WPEM, the sensors performed well. Setup and data download was trouble-free, making field use of Hidalgo units practical and feasible. Data management performed well, but it was sometimes difficult to convert to other data formats. Some telemetry pills died or read too low. CT changes little despite fluctuations in RR and HR. Those data, collected from the Hidalgo system, appear reasonable for WLFF activities.				
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EXECUTIVE SUMMARY

This report consists of two parts, a review of the Hidalgo Equivital™ Physiological Monitor and other body mounted devices for monitoring physiological status, and a brief overview of the human data collected on 12 wildland firefighters (WLFF) actively engaged in fighting two fires in the western U.S. over a 3-day period. The physiological sensors were provided by U.S. Army Research Institute of Environmental Medicine (USARIEM) for use in conjunction with a previously planned University of Montana's Center for Work Physiology and Exercise Metabolism (WPEM) study to collect additional data relative to energy costs and thermal strain experienced during wildland fire suppression. The human data collected included activity patterns, core temperatures (CT) and skin temperatures (ST), heart rate (HR), and respiratory rate (RR). Other test data included body weight, activity patterns, and dietary intake. Weather data were also collected.

The Hildago system was used to collect, record and display heart rate (HR), respiratory rate (RR), body position, skin temperature (ST) and core temperature (CT). The later measurement, CT, was obtained using the VitalSense® system/monitor with ingestible temperature pills. Other sensors used were an ActiCal® activity monitor and Garmin Forerunner® 301 GPS locator. Relative to other sensors and systems used in previous studies by WPEM, the sensors provided by USARIEM performed well.

Specifically, the Hidalgo units collected complete HR and RR data during the work shifts, which had been a prior difficulty for WPEM. Hidalgo setup was quick and trouble-free, and the devices withstood the rigors of a day's work of wildland fire suppression. Data download was quick and easy, making the use of Hidalgo units in the field practical and feasible. Data management, an often overlooked aspect of sensor systems, was well thought out, and in practice performed well. There was some difficulty in converting the down-loaded data to other data formats. Some problems were experienced with the VitalSense® system which uses ingested telemetry pills to measure core temperature. Specifically, some pills died after administration, while others provided periodic bouts of low temperature readings. The key value of the Hidalgo unit for WPEM is the capability to reliably measure HR and RR, since this laboratory has had difficulty obtaining these measures using other portable monitoring systems.

Only a brief overview of the human data is presented. The data collected from the Hidalgo Equivital™ Physiological Monitor appear reasonable in light of the nature of wildland fire suppression[1-3,5,6]. Core body temperature changes little throughout the day, despite fluctuations in respiratory rate and heart rate. Body weight, activity, and dietary data were similar to previous investigations with WLFF by WPEM [1-3]. However, the distribution of work intensities on Day 3 (sedentary ($47\% \pm 9$), light ($46\% \pm 9$), and moderate/vigorous ($7\% \pm 3$)) was the most diverse seen from any previous WLFF study from this lab. Typically sedentary activity is ~66%[2], but the time spent in the light and moderate/vigorous categories was higher on Day 3.

INTRODUCTION

Researchers from the University of Montana's Center for Work Physiology and Exercise Metabolism (WPEM) have used numerous monitors to acquire physiological data during wild-fire suppression in order to describe the job demands and habits of wildland firefighters (WLFF)[1-3]. Some of these monitors include CSA Activity Monitors, Actical®, Actiheart®, VitalSense®, and Polar Heart Rate Monitors. For data collection with WLFF, the most robust of these devices are the Actical® and VitalSense® system; researchers have not had much success with Actiheart® and Polar Heart Rate Monitors. The primary problem associated with the acquisition of heart rate data has been the inability for monitors to remain in place when a pack is worn and the participant is sweating profusely (Actiheart®). Other problems include participants tampering with watches, thus making downloads time consuming and incomplete due to missing data points (Polar Heart Rate Monitors).

The Hidalgo Equivital™ physiological monitors are a compact, lightweight, chest-strap monitor system that collects heart rate, skin and core temperature, body position, and respiration rate. When coupled with the program's software and Bluetooth® technology, researchers and participants can view data in real time. Data are stored using Micro SD Memory cards, and are downloaded to a computer using a USB compatible memory card reader. From there, a series of steps are implemented to get data to a workable and easy to use format. Overall, the data collection with wildland firefighters using the Hidalgo units was successful. This report will highlight the strengths and weaknesses of the Hidalgo Equivital™ physiological monitors as experienced by The University of Montana researchers during a study with WLFFs. It will address the following areas: software, preparation, data collection, download, data conversion, and key strengths and weaknesses.

SOFTWARE

The Hidalgo software is a beta version and the emphasis has been on function, thus it is not wholly user friendly. However, the directions for setup and use were easy to follow, and after approximately 1.5 hours of setup, we had everything running smoothly. During setup we did not have one software malfunction, but during setup in the field, the program restarted the computer four or five times. The ease of setup benefited the research team by avoiding time wasted on troubleshooting measures. The installation and application of the software and Hidalgo unit, respectively, was far simpler than we had previously been led to believe. However, there was a plethora of directions and steps that could easily frustrate consumers. A streamlined version would benefit future users.

The real-time component of the software program proved to be both a novel and useful tool. It was easy to tell if the Hidalgo unit was turned on and functioning properly. For some monitors we use/have used with projects, such as Actical®, Trackstick™, and Actiheart®, there is no way to discern that the unit is collecting data. In some, a light indicates that the unit is on; however, determining if the device is recording properly proves impossible until after data collection. With the Hidalgo

units we could get real-time feedback and see that their respiration, heart rate, body position, core temperature, and skin temperature were being picked up. Knowing that a device is working properly when sending the subjects into the field is great comfort for a researcher.

The other reason the real-time software was such an advantage is that it intrigued the study participants. A large majority of WLFFs are college-educated, late 20s/early 30s, lead healthy, active lifestyles, and are interested in health and fitness. They understand the basics of physiological monitoring, and quickly catch on to concepts like core and skin temperature differences and how the gradient between the two is critical for loss of heat. Participants enjoyed gathering around the computer and comparing their different numbers and asking what they meant. They thought it was fun to watch their core temperature change from ambient to gut temperature, as well as watch the stick man mirror their changing body positions. Actually seeing their numbers in real time and watching changes opened the door for communication and explanation of different physiological processes. In the past, these interactions with the participants would not have occurred.

Briefly, it is exciting to think of the possibilities of this software, considering that, as a neophyte, it has proven to be both a useful and beneficial program. The primary struggle is the long setup process, but that will most likely be streamlined. The software has the potential to be used as an educational tool with participants and provide them with more interesting facts than may be typically acquired from field research.

Grade: B

PREPARATION

Compared to other field research devices, the Hidalgo Equivital™ physiological monitors were incredibly easy to initialize and administer to subjects. Having to only put batteries in and wait for the vibration could not be any easier. While at first it was difficult to trust that the devices were recording, the real-time feature on the computer quickly dismissed doubts. It was easy to snap the devices to the belt, and subjects had no difficulties putting them on. Female participants needed to go to a private location, but this posed no logistical challenge. One of the most critical tasks was to record the time of initialization and administration to participants, since the Hidalgo download did not have time stamped data. This should be a feature that gets incorporated into future units, for there will be times when researchers forget to record the exact time. One of the best features of preparation was that a computer was not necessary to initialize the units. For field research, this was extremely handy. If we had been in a particularly remote location and had no access to power, we could have completed data collection smoothly. Additionally, initialization is quick, and we could put batteries in all 12 monitors in less than one minute. This kind of time efficiency and the lack of administration challenges are unmatched by any other piece of field equipment we have used thus far in our work with WLFFs.

Grade: A

DATA COLLECTION

Perhaps the most impressive feature of the Hidalgo Equivital™ physiological monitors is that the acquired data was complete, and appears to be in agreement with previous wildland fire studies. No laboratory control values were available to validate the data with wildland fire suppression tasks, but the data align with typical physiological values seen for sedentary to vigorous exercise. Clearly, our project was not a validation study, but from observation the data look very reasonable. There seem to be little, if any, missing data points for skin temperature, heart rate, and respiration rate.

The only variable that had some false data, or missing data points, was core temperature. Most likely this was not due to a malfunction of the Hidalgo Equivital™ physiological monitor, but rather the core temperature sensors. In recent projects, roughly 20% of our pills either died or provided choppy/sporadic data when using the VitalSense® system. In this study, 4 subjects had entirely incomplete or choppy core temperature data (out of 24 man days). One subject's pill died shortly after leaving camp prior to beginning his work shift. Another subject's data that were lost for every variable was due to download issues (which will be addressed in a later paragraph). Another participant's pill died 4 hours into the shift, while another had consistent data that would read 0.0 or display values in the low 30s. For the other 20 subject-days, sporadically throughout the day a certain subject's core temperature would randomly read 0.0 or a value in the low 30s; however, there was not a consistent pattern. All in all, three of the participants' core temperature data collections were not salvageable for the entire day, a 12.5% data loss (much better than our recent experience with the VitalSense® system).

One of the most promising aspects of the Hidalgo Equivital™ physiological monitors is the ability to gather all of the aforementioned variables with one unit. They are the first monitors this laboratory has used during actual wildland fire suppression wherein heart rate data were accurately and easily collected. The potential for physiological modeling for heat and/or work stress during wildland fire suppression would be highly likely because of the reliability and diversity of data collected by the Hidalgo units. Though we do not understand how to interpret the body position numbers yet, they have great potential to inform researchers as to the activities being engaged in by WLFFs, such as hiking, where the torso would be vertical, or digging, where the torso would be more horizontal, or if WLFFs are taking a midday nap! In short, other than a few minor glitches with core temperature data collection, the Hidalgo units were **exceedingly reliable** in their physiological monitoring.

Participants in the study felt like the monitors were uncomfortable as the day progressed. For male participants, wearing something on the chest was not a familiar sensation. They felt it was tight and constricted their breathing at times. There was no issue of fabric rubbing on the skin and causing irritation. For the women, the monitor went under their sports bras and squeezed the bra tighter than normal. However, both males and females remarked that when they were working

hard they did not notice the monitor. No subjects got annoyed to the point of removing them or complaining excessively about them. The feedback we received was more along the lines of the monitors being unpleasant, but not unbearable. From a researcher standpoint, they are less cumbersome than if researchers wanted to collect data equivalent to that of the Hidalgo Equivital™ physiological monitor with different devices. For example, participants would have to wear an Actical®, VitalSense® system with a skin patch, and a Polar Heart Rate Monitor. They would also need to wear a device that measures respiration. In short, in order to collect the same data as the Hidalgo Equivital™ physiological monitor, participants would have to wear four to five separate units. This would be cumbersome for them, and there would be increased opportunities for error and/or lost data in regards to the initialization, collection, and downloading of multiple devices.

Grade: A

DOWNLOAD

Perhaps the easiest feature of the Hidalgo Equivital™ physiological monitor is the downloading of data from the unit to the computer. Once the memory card reader is recognized and able to be used on the computer, downloading is a breeze. Simply, pop off the battery cover on the Hidalgo unit, eject the memory card, and stick it in the reader. Then drag the sensor electronics monitor (SEM) file from the memory card to the designated folder in which you wish to put your raw data. This proved to be the easiest download from any monitor used thus far in our field research experience. It takes little time, there are no cables, and there are not a multitude of prompts to follow while working on the computer. The idea of a memory card is an excellent option due to the ease of purchase and their potential to store multiple days worth of data. In addition, a memory card could easily be replaced with a backup if multiple days were going to be collected and access to computers was limited. Researchers would be able to collect data by simply changing memory cards instead of downloading the data. This technology further expands the ability of the Hidalgo Equivital™ physiological monitors to be superior field devices for physiological data collection.

Grade: A

DATA CONVERSION

The most difficult and time consuming part of working with the Hidalgo units was the conversion of data from SEM files into manageable Microsoft Excel files. To get the data ready for statistical analysis, it took 8 separate steps: download the raw data, convert SEM file to multiple text files, separate out the 15s files, convert 15s .txt files to .xls files, add time in column A of spreadsheet, build a macro to separate data, compile all subjects' data together, and then organize data for statistical analysis.

When the SEM file converts its data into multiple .txt files, the 15s file must then be converted to an .xls file. While not a difficult task, having to separate and

then convert 24 individual files takes considerably longer than if they downloaded as .xls files. If this is not possible, it would be nice to have a feature in the software that could convert 24 files at once the same way, rather than having to open them individually (similar to MiniMitter's Actical® program). Even to save one step, the Hidalgo unit could record data into a .txt file, so then one could just download the .txt file and not have to go through the SEM conversion.

As mentioned above, it would be ideal if you could convert and organize multiple SEM data files at once. For example, if you placed 24 SEM files into a folder, highlighted all of them, and then converted them at once so the 15s data .txt files, or any data from .txt files, would align into one folder. With these .txt files, it would be nice if a program could organize data the way the end user would like it by allowing the user to select various options (similar to MiniMitter's VitalSense® system). It would be like a giant macro where the user could choose what data he wants organized and how it should be done. For example, a researcher could check boxes like, "Skin Temperature," "Core Temperature," "Heart Rate," and "Respiration Rate." Then the researcher could select how he wants them averaged: "15 seconds," "30 seconds," or "1 minute." He could even select which subject files he wants to have in the data compilation, allowing a way to sort subjects by different interventions or days in the study. Then with a click of the button it would sort the data into an .xls file that could be used for data organization and analysis.

Grade: D

SUMMARY OF STRENGTHS AND WEAKNESSES

In short, the compact and efficient design of the Hidalgo Equivital™ physiological monitor is unmatched compared to any other pieces of field equipment researchers from this laboratory have used during studying the physiological effects of wildland fire suppression. If the above categories were weighted equally and numerical scores assigned to the letter grades (A=5, B=4, C=3, D=2, F=1), the composite score would be 4.2, or a B. The primary strengths of the units are the ease of initialization, the validity of data collected (assuming they are shown valid), the ease of download, and the robust nature of not needing sophisticated equipment (e.g., computers, downloaders) to collect multiple days of data in a field environment. The primary areas for improvement are a streamlined software setup, an easier way to convert files into .txt and/or .xls files, and a more in-depth explanation of the meaning of acquired numbers on the spreadsheets, particularly accelerometer data. The Hidalgo Equivital™ physiological monitor's superiority in ease of data collection and memory capabilities for a field instrument that monitors physiological data are impressive and have the potential to be a valuable asset during field research in arduous work environments.

METHODS

EXPERIMENTAL DESIGN

Participants (N=12, 86 ± 9 kg, 184 ± 7 cm) were recruited from a Type Interagency Hot Shot fire crew over 3 days (Days 1 and 2 (Elmo Fire), n=6 each day, and Day 3 (Eureka Fire), n=12) during the summer of 2008. Prior to participation, subjects provided informed consent by signing a university approved institutional review board consent form. Participants arrived to the mobile laboratory in the AM prior to beginning their work shift. Upon arrival, participants were weighed and verbally provided their height. Subjects ingested a disposable temperature transmitter pill, were equipped with the Hidalgo Equivital™ physiological monitor and an activity monitor, and provided notebooks for recording work shift activity data. Two participants were equipped with a global positioning system (GPS) wristwatch to track movements throughout the day. After being equipped with the sensors, participants went to work, which involves activities such as hiking, line digging, laying hose, chain sawing, clearing brush, lookout, and scouting. Work shifts were 8.8 ± 1.5 hours in duration. Participants reported to the mobile laboratory following the work shift, were weighed, and returned the monitors. Researchers reviewed food and activity logs with participants to ensure accuracy.

DATA COLLECTION

Weight

Participants were weighed wearing boots, pants, and a t-shirt pre- and post-work shift using a calibrated scale (Ohaus CW-11, Pinebrook, NJ).

Ingestible Sensor

Researchers initialized a Jonah™ Ingestible Sensor using a VitalSense® monitor system prior to subject arrival to the lab. Participants ingested the sensor prior to eating breakfast. Following pill ingestion, participants consumed approximately 8 ounces of fluid. Breakfast was consumed within 30 minutes of pill ingestion. Researchers monitored subjects while they were at the laboratory to ensure it passed from the stomach into the intestines. Three pills died shortly after ingestion, but were replaced prior to subjects leaving the research premises. Three other pills died after subjects left the researchers; two died prior to beginning the work shift, and one died approximately 1/3 of the way through the work shift. Thus, out of 24 total subject days, 3 days of core temperature readings were lost. In addition, periodic dips in core temperature readings occurred with some subjects, with temperatures falling 1 or more degrees below the temperature at which the subject had previously been stabilized. This is likely due to cool water ingestion during the work shifts[7]. For the figures, random low temperature data points less than 36.3°C were dropped.

Hidalgo Equivital™ Physiological Monitor

Subjects were equipped with the Hidalgo Equivital™ physiological monitor according to manufacturer's directions. The sensor measured heart rate, respiration rate, skin temperature, body motion, and body position. The system has been certified by the Food and Drug Administration (FDA). The system was checked in real time on a computer using Hidalgo software and Bluetooth technology to ensure proper function. Participants wore the monitor for the entire work shift. Data were downloaded onto a computer and converted into .xls files for data analysis.

Activity Monitor

Activity counts were obtained using ActiCal® activity monitors (MiniMitter, Bend, OR). The monitors were initialized and distributed to crew members to determine activity counts during one day of firefighting. Researchers placed ActiCals® in the left chest pocket of the Nomex fire shirt. For protection, stability, and in order to keep the unit in a secure position, each monitor was secured in a white foam core square (7.6 cm x 7.6 cm). This location was chosen due to the amount of upper body movement associated with WLFF. Activity counts were averaged into one-hour intervals and were expressed in counts·min⁻¹. Due to differences in work shift lengths among the three days, work shifts were divided into 8 equal segments for each day [4]. The three work shift lengths were 10:00, 7:05, and 9:10 respectively. Dividing each work shift into 8 segments yielded shift lengths of 1:15, 0:53, and 1:08 h, with a mean length of 1:05 +/- 0:11 h (Fig 1).

Diet and Activity Log

Participants were allowed to eat and drink *ad libitum* throughout the day. Each subject was provided a notebook and pencil to record food/drink consumed. For analysis, nutrition fact labels were used when available. In addition, The Food Processor Nutrition and Fitness Software (ESHA Research, Salem, OR) program was used when food items did not have nutrition fact labels. Participants recorded work tasks throughout the work shift, and the times associated with these jobs. At the end of the work shift, researchers reviewed the logs with each individual participant to ensure accuracy.

GPS System

Each day two participants were equipped with Garmin Forerunner® 301 GPS (Olathe, KS) systems to log movement patterns, vertical gain/loss, and distance covered during each of the fire shifts. The units were secured to the top of subjects' packs to provide uninhibited satellite reception.

RESULTS

ELMO FIRE

Body Weight

There was a significant decrease in body weight on Day 1 (89.6 ± 8.4 and 89.0 ± 8.3 kg for pre- and post-shift, respectively, $p<0.05$). In contrast, body weights were similar pre- to post-shift on Day 2 (83.3 ± 9.0 and 83.5 ± 8.9 kg for pre- and post-work shift, respectively).

Activity Patterns

Activity patterns were similar on Day 1 and Day 2 (191 ± 40 and 241 ± 134 counts·min⁻¹, respectively, Figure 1). There were no differences between days for percentage of time spent at sedentary (72% \pm 7 and 72% \pm 10 of time for Days 1 and 2, respectively), light (25% \pm 7 and 24% \pm 7 of time for Days 1 and 2, respectively), and moderate/vigorous (3% \pm 1 and 3% \pm 4 of time for Days 1 and 2, respectively) intensities.

Dietary Intake

Total energy intake was greater on Day 1 compared to Day 2 (2562 ± 623 and 1754 ± 484 kcals·d⁻¹, respectively, $p<0.05$). Similarly, total carbohydrate intake was higher on Day 1 compared to Day 2 (367 \pm 83 and 258 \pm 43 grams·d⁻¹, respectively, $p<0.05$). Carbohydrate intake relative to body weight was similar between Days 1 and 2, amounting to 4.1 ± 1.0 and 3.1 ± 0.5 g·kg⁻¹·day⁻¹ for Days 1 and 2, respectively.

Hidalgo Data (Core and Skin Temperature, Respiratory Rate, and HR)

Core and skin temperature data, and respiratory rate, can be seen in Figures 2 and 3. Heart rate data can be seen in Figure 5.

EUREKA FIRE

Body Weight

Body weight was not measured on Day 3 due to the remote location of the fire.

Activity Patterns

Mean activity was 399 ± 97 counts·min⁻¹ (Figure 1). The percentage of time spent at different intensities was sedentary ($47\% \pm 9$), light ($46\% \pm 9$), and moderate/vigorous ($7\% \pm 3$).

Dietary Intake

Dietary intake was not recorded on Day 3 because Day 3 was not done in conjunction with the biopsy study being completed.

Hidalgo Data (Core and Skin Temperature, Respiratory Rate, and HR)

Core and skin temperature data, and respiratory rate, can be seen in Figure 4. Heart rate data can be seen in Figure 5.

Figure 1. Activity patterns during the work shift for Day 1-3

Figure 1. Activity patterns during the work shift for Day 1-3

Activity Patterns

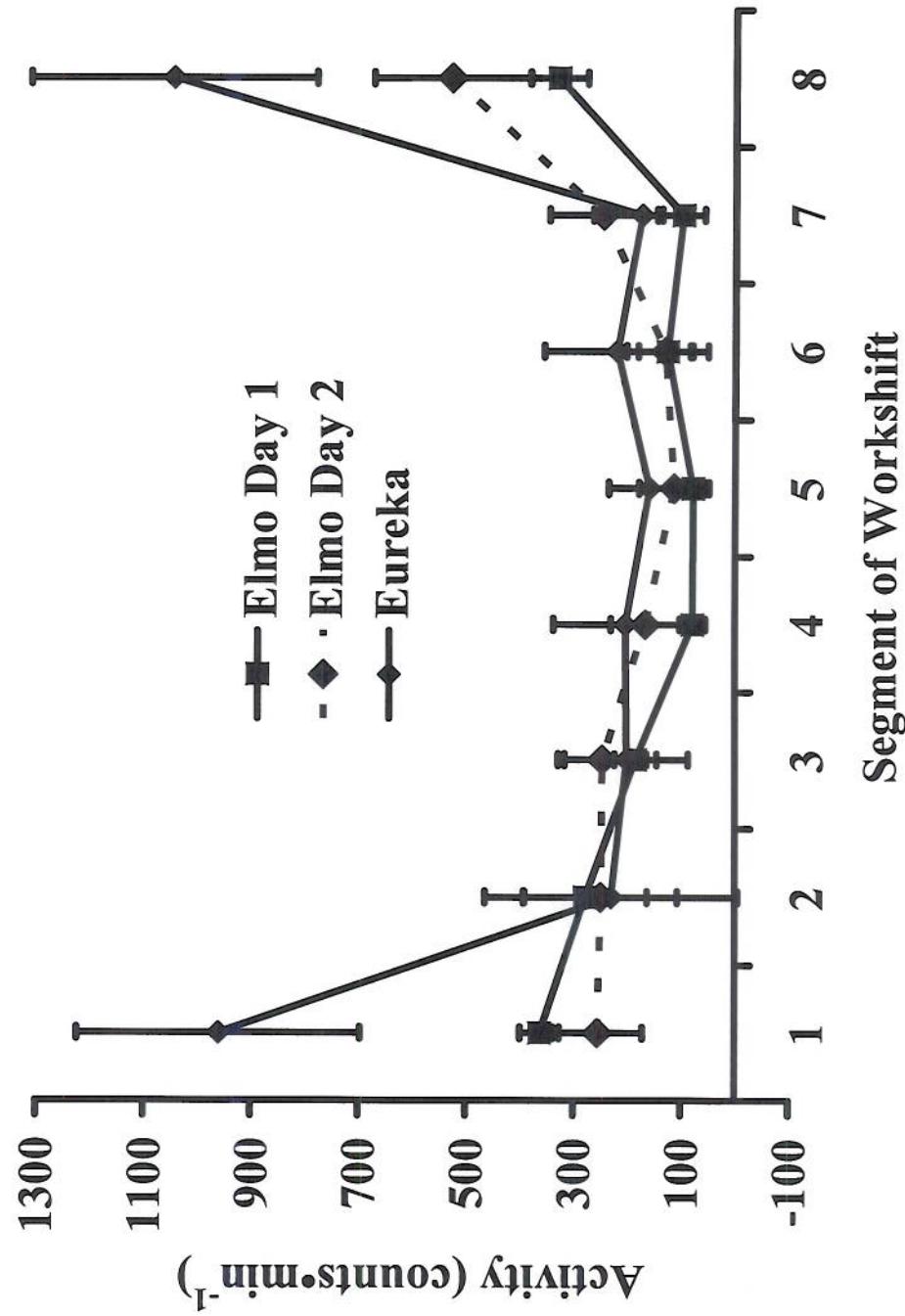


Figure 2. Core and skin temperature and respiratory rate on Day 1 of the Elmo fire

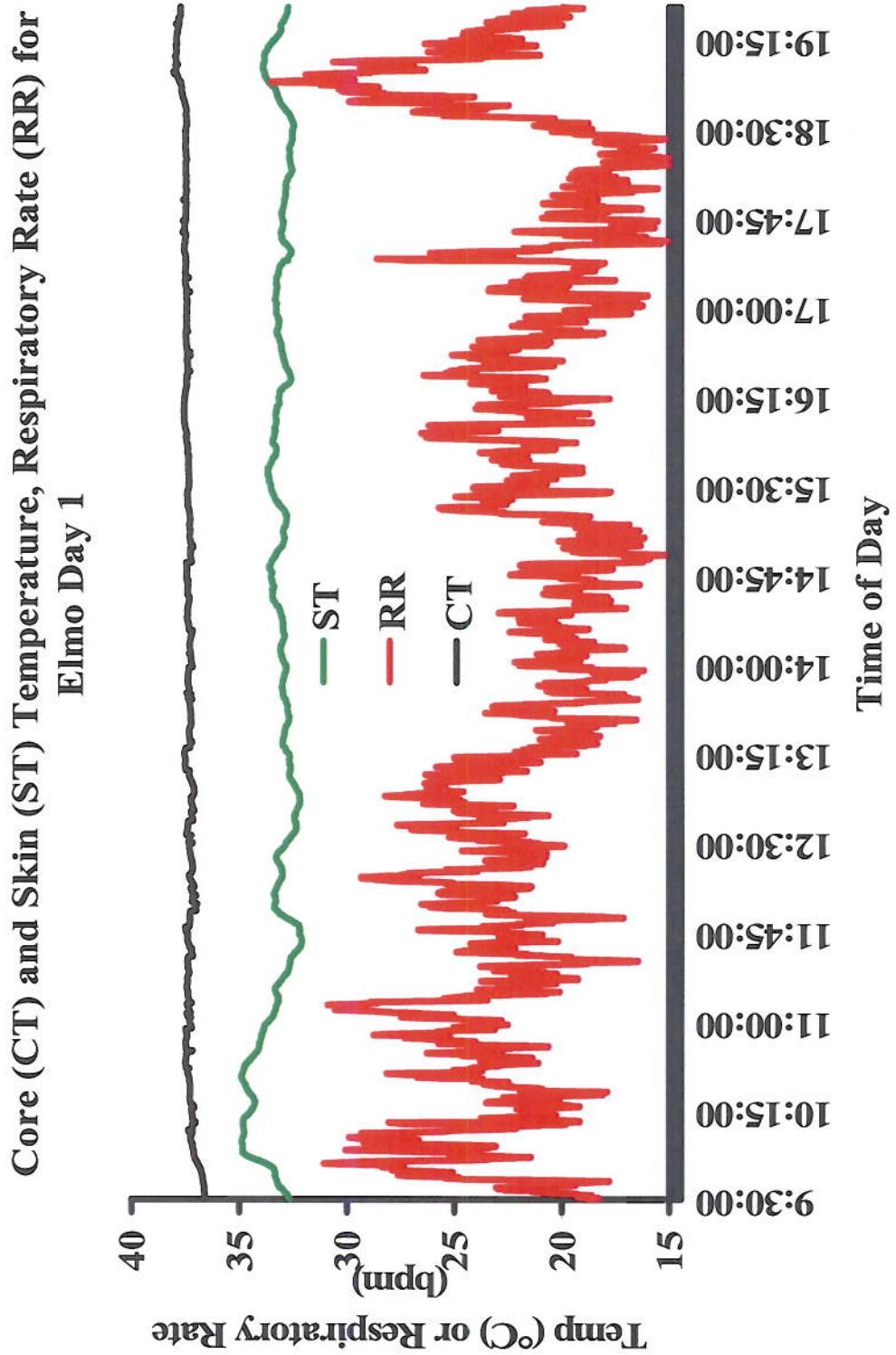


Figure 3. Core and skin temperature and respiratory rate on Day 2 of the Elmo fire

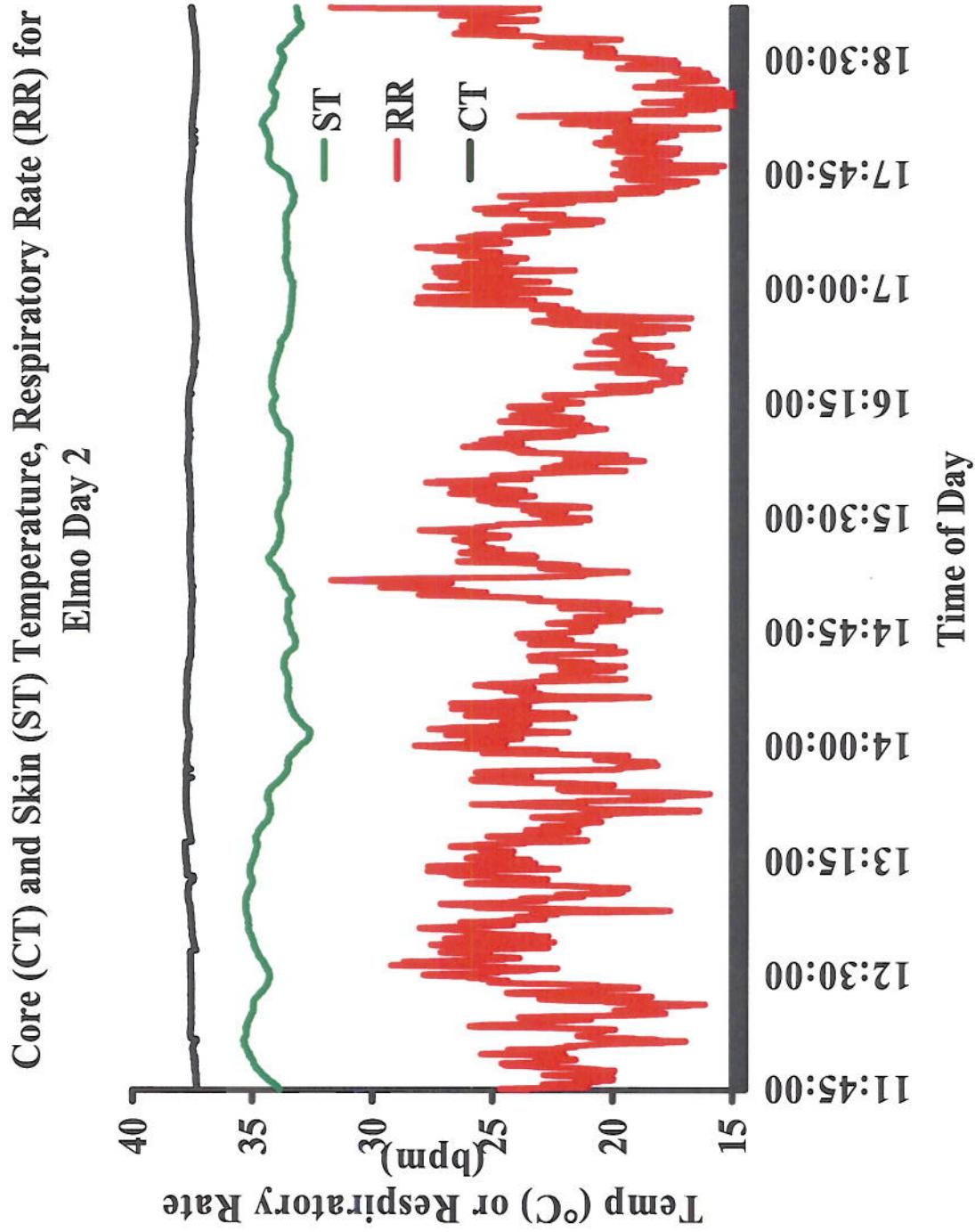


Figure 4. Core and skin temperature and respiratory rate during the Eureka fire

Core (CT) and Skin (ST) Temperature, Respiratory Rate (RR) for
Eureka Fire

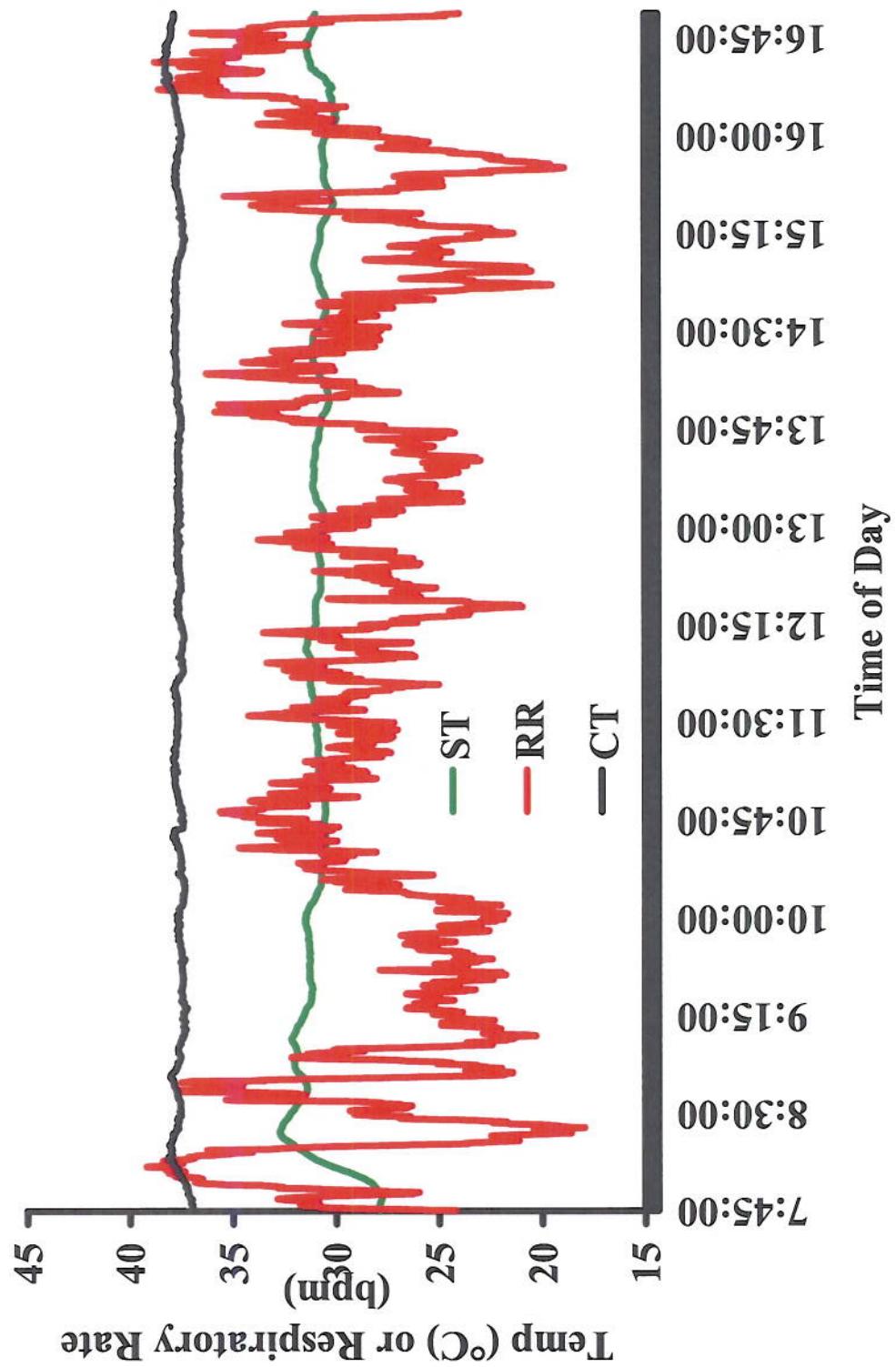
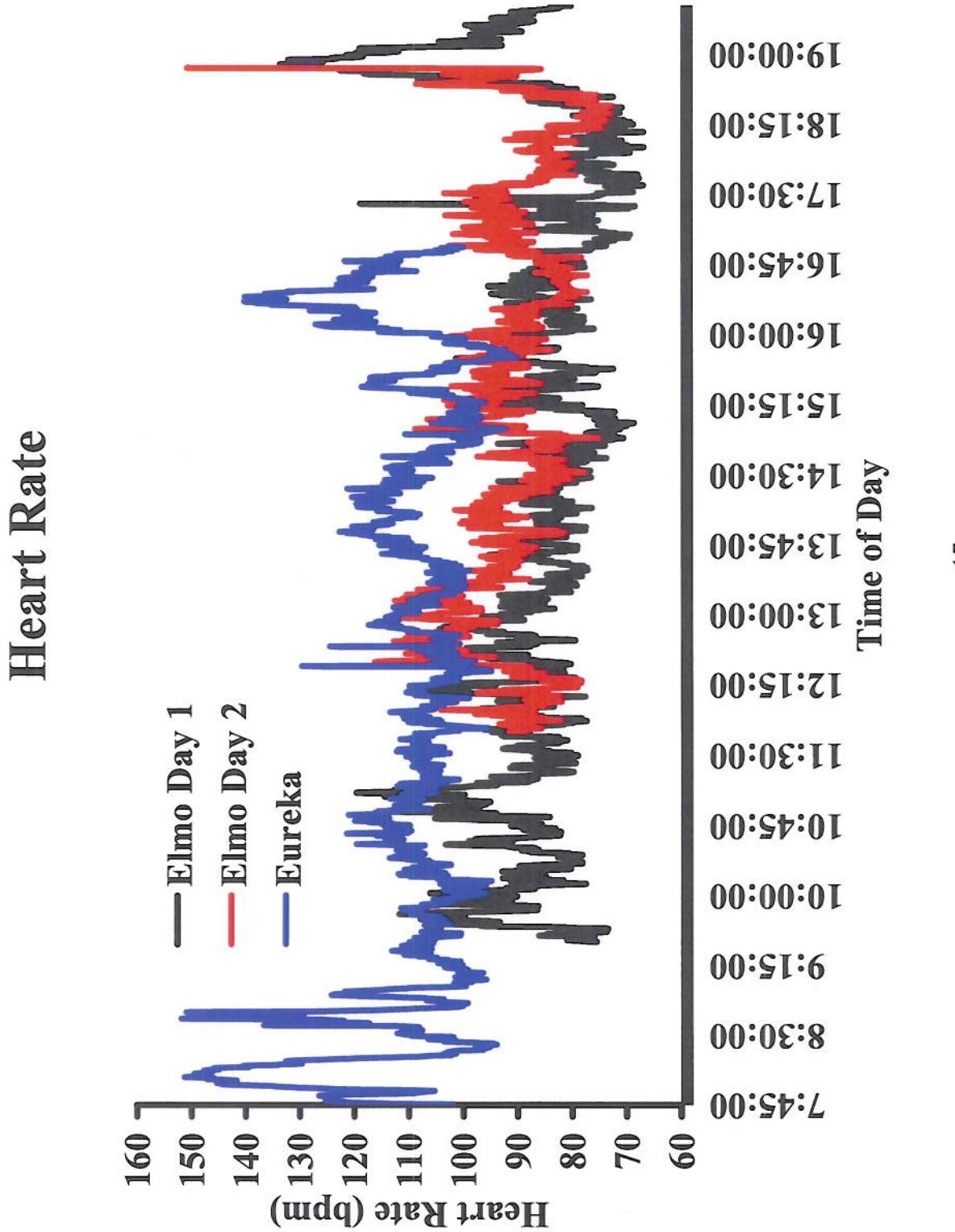


Figure 5. Heart rate during 3 days of wildland fire suppression



DISCUSSION

The strengths of the Hidalgo Equivital™ physiological monitor units include the ease of initialization, the ease of download, and no requirement for additional hardware to collect data in a field environment. The units performed well in comparison to any other devices researchers from WPEM have used during studying the physiological effects of wildland fire suppression.

The primary areas for improvement are improved software for setup, easier conversion of data files into alternative formats, and more detailed explanations of the acquired numbers on the spreadsheets. As a field unit for monitoring physiological data in a challenging environment, in terms of both the physical environment and the range of activities, the Hidalgo units demonstrated superior capabilities in terms of the ease of data collection and the memory capabilities. The Hidalgo units have the potential to be a valuable asset during field research in arduous work environments.

The values for the physiological parameters are within the limits which would be expected based on prior WPEM studies[1-3,5,6]. Thus the data collected appears valid, but there were no independent or control values for comparison. The accelerometer data from the Hidalgo units was, in the absence of a more detailed explanation from the developers, somewhat difficult to interpret.

As noted, CT data below 36.3°C were removed. This is probably a reflection of several related problems inherent in the passage of an ingestible pill through the digestive system during normal activities that include eating and drinking. Other problems with the temperature pills were noted. Alternative methods for monitoring CT, such as esophageal or rectal probes, have the advantage of a fixed location, and may be more reliable in a laboratory setting, but are more invasive and/or intrusive. Despite the current short-coming of telemetry temperature pill systems, at present there is no practical alternative for a direct measurement of CT under free-ranging field conditions. Figure 1 reflects the activity patterns of WLFF during the two fires. Typically work shifts begin with a hike into the fire and end with a hike back to the trucks. Thus, spikes in activity are seen at the beginning and end of work shifts. During the work shift, firefighters maintained a relatively steady work pace. The physiological data collected by the Hidalgo units coincides with the Actical® data (See Figs 2-4), since the physiological measures stay relatively constant. In Figure 5, heart rate data demonstrate the hikes in and out of fires, and the consistent pace of work. Also, it is clear that Day 3 was a harder work day compared to Days 1 and 2.

CONCLUSIONS

Body weight, activity, and dietary data were similar to previous investigations with WLFF from this laboratory[1-3]. Days 1 and 2 had lower activity data than has been previously reported, but Day 3 was more typical. However, Days 1 and 2 were in steep terrain, which can sometimes underreport activity counts compared to the amount of work actually being completed. The distribution of work intensities on Day 3 (sedentary ($47\% \pm 9$), light ($46\% \pm 9$), and moderate/vigorous ($7\% \pm 3$)) was the most diverse seen from any previous WLFF study from this lab. Typically sedentary activity is ~66%[2], but sedentary time was less and time spent in the light and moderate/vigorous categories was higher on Day 3. During wildland fire suppression, the job demands dictate the activity patterns of the crewmembers. Day 3 was the first day on the Eureka fire, and WLFFs performed initial attack. In such cases the crew, for the most part, stays together and performs similar job tasks throughout the day. These are more arduous work days, and this is demonstrated by the less time spent in the sedentary category.

The data collected from the Hidalgo Equivital™ Physiological Monitor appear reasonable in light of the nature of wildland fire suppression. Core body temperature changes little throughout the day, despite fluctuations in respiratory rate and heart rate. This would be expected, as the body compensates for changes in work rate by sweating more or less to maintain core body temperature. The key components of the Hidalgo unit's data for this laboratory are the measures of heart rate and respiratory rate, since this laboratory has had difficulty obtaining these measures using other portable monitoring systems.

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